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The importance of a fixed crossing (over the Great Belt)
for the fisheries in the Baltic

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The importance of a fixed crossing (over The Great Belt) for the fisheries in the Baltic.

(En fast forbindelses betydning for fiskerimulighederne i østersøen)

by

Hans Frost and Henning Peter Jörgensen

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Table of content

Page

1. Socio-ecocomic profitability calculations	6
2. Calculations of salt and oxygen content in the Baltic Sea	10
3. The catch in the Baltic Sea	12
4. Recruitment and salt and oxygen content (page or pages missing in original. Translator's note.)	
5. The socio-economic value per kg cod	20
6. Socio-economic loss	22

Preface

In the debate over the establishment of a fixed crossing over the Great Belt, the environmental impact on the Baltic Sea has often been discussed. Research and economic calculations concerning a fixed crossing do not specifically assess the effects of such construction on pollution, ice conditions and fishing potentials, due to a high degree of uncertainty in these matters.

The purpose of this report is to attempt to quantify the potential influence on the cod fisheries of a fixed crossing, because cod is the most valuable species of fish in the Baltic Sea. The less valuable species of fish called sprat will also be affected.

A fixed crossing over the Great Belt is important for the fisheries since there would be a reduced area for the water to flow through. This can reduce the salinity and oxygen content of water flowing into the spawning basins of the Baltic Sea. This in turn can have possible negative effects on the spawning and fishing potential and value and growth in fishing and associated industries. In this report, primary emphasis is placed on the last link in this chain of events.

January 1986

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Summary

This report is a contribution to the debate over the form a fixed crossing over The Great Belt will take. The background documents used are "The 85 report on The Great Belt " and "A fixed crossing".

Since a fixed crossing over The Great Belt increases the resistance of the flow of oxygen and salt-carrying water masses to the Baltic, there is a danger that the environment will be affected. The following report contains a calculated estimate of the consequences for the cod fishery and thereby the contribution of the fishery and associated industries to the gross national product (value added). Of other species, it is especially the less valuable sprat that will be affected.

When the resistance to water through-flow is increased, the supply of salty, oxygenated water to the Baltic spawning areas for cod will decrease. Conditions for spawning and hatching for the cod stocks and opportunities for catching will thereby be negatively affected.

The salinity will, depending on the plan chosen, be reduced by between 0.3 and 0.7 per mille in the upper layers of the Bornholm Basin from an undisturbed level of 7.8 per mille (0.78‰) based on the proposals discussed in the two reports mentioned above. Changes in salinity decrease with depth of water and increase towards the northeast in the Baltic.

Based on biological information on the importance of the salt and oxygen content for recruitment to cod stocks, the average yearly catch loss is calculated based on a reduction of salinity of 0.5 per mille in the Bornholm Basin.

The loss is calculated to be 76.5 million cod a year corresponding to 42,000 tonnes. The total Danish loss in value added is calculated to be 12.05 D.kr. per kg cod measured in 1984 prices.

Denmark has traditionally caught ca. 25% of cod in the Baltic so ^{that} Danish catch losses can be estimated at 10,500 tonnes.

p.3

It is assumed that 33% of the Danish drop in catches can be replaced with imported cod so ^{that} the Danish processing industry only loses 7000 tonnes. This means that the Danish loss per kilo cod will be 9.48 kr. From this the estimated Danish losses in value added can be calculated to be ca. 100 million kroner per year (10,500 x 9.48 kr).

Since it is not expected ~~that~~ good alternative employment opportunities ^{are} available for the labor and capital tied up in the fishing and associated industries, losses will increase year by year. With the opening of the fixed crossing on Jan 1, 1995, as originally estimated in the above mentioned reports, it can be seen that losses will show up from 1997, since dams, etc. will have been constructed in the beginning of the 1990's.

The present value of losses in future years is based

on a real interest of 7% per year calculated back to 1984 which makes losses directly comparable with the Nyboe Anderson Committee calculations in "A fixed crossing". Present value to 1984 totals 593 million kroner. The amount is not comparable with "The -85 Report", from the Ministry of Public Works where the present value is calculated to the year 1995.

In the last half of 1985, several changes in the plans for tunnels and bridges were made in order to find situations that were neutral to the Baltic. These changes resulted in increased construction costs in the 0.4-0.9 billion kroner range depending on the solutions chosen and if a deepening of The Great Belt were to be carried out right away. It should be pointed out that these numbers are not immediately comparable with the construction costs given in the above mentioned reports on construction costs, since slightly different methods of calculation were used.

The conclusion of the calculations carried out by the Institute of Fisheries Economics on the consequences of a fixed crossing over The Great Belt is therefore, that by considering lost value added as a result of poorer fishing conditions, the solutions will have a poorer national economic profitability than given in the above mentioned reports. However, none of the solutions can for that reason be considered to be poor long-term investments.

p. 4

It can furthermore be concluded that the cost increases incurred as a result of planning changes that are neutral

to the Baltic, are largely cancelled by the fact that losses in catches and value added in the order of magnitude mentioned are not as likely to occur. In addition, the increases in construction costs will be much lower than the estimated losses that all Baltic countries are likely to incur if the improvements in the fixed crossing over The Great Belt were not carried out. Due to lower value added in the other Baltic countries than in Denmark, the total loss is estimated to be in the range of three times the estimated Danish losses.

1. Socio-economic profitability calculations.

(5)

An essential part of the discussion concerning a fixed crossing over the Great Belt can be found in technical economic reports. These reports make a quantitative comparison between the benefits and drawbacks of the project from a sociological point of view, beginning with the alternative technical formulations of a fixed crossing. It is no easy task to decide which benefits and drawbacks to include in such calculations. To base the calculations solely on a quantitative economic assessment will not provide the best solution. It will be necessary to supplement the calculations with non-quantitative considerations. However, the advantage of quantification is in the creation of a single figure showing the advantages of the alternatives compared to each other. Similar socio-economic profitability calculations have been presented in "The 85 report on the Great Belt"¹⁾ and "A fixed crossing"²⁾.

The purpose of this report is to quantify considerations about the impact of the project on the Baltic Sea environment.

1) The 85-report on the Great Belt. The Department of Public Works 1985.

2) Nyboe Andersen, P., Nils Groes and Hans Zeuthen (1985): A fixed crossing. Ownership conditions, financing, employment, balance of payment and profitability. Department of Public Works.

Until now, this has only been dealt with on a more qualitative level. Further limiting factors also arise. A fixed crossing can be considered as an extra load on the Baltic. This means that this additional expense for society must be included in the socio-economic profitability calculations of a fixed crossing. If the purpose is to maintain the status quo, the calculations will be further complicated. It may be less (6) expensive for society to build a fixed crossing that has negative effects on the environment but is cheaper to construct. Subsequently, the load on the Baltic Sea can be eased by, for example, reducing pollution.

The present study is limited to include only the fisheries, for the sake of quantification. This means that it is fully excluded that benefits per krone by limiting pollution, for instance, can be greater than benefits from the cost increase of one krone in building expenses for a fixed crossing. In principle, the purpose of this report is to show the magnitude of the socio-economic loss that a fixed crossing will inflict on the fisheries in the Baltic Sea; in other words, how much extra it may pay to invest in a fixed crossing in order to avoid the possible loss. Since these results will be viewed in light of the socio-economic profitability calculations in the two previously mentioned reports, the main findings in these reports will be presented later in Table 1.

Although "The 85 report on the Belt" contains a number of alternative solutions, the official debate reflects most interest in two solutions; one low bridge laid out south over the West Channel and one bridge over the East Channel for a

road and railroad or a tunnel for train and motorail. These two alternatives are also dealt with in the report "A fixed crossing". The bridge solution is a cantilever bridge with a four lane road and two railroad tracks. The span over the navigation channel in the East Channel is 780 meters. This means that the bridge pillars must be placed out in deep water in the navigation channel. A suspension bridge is assumed to cost 500 million kroner more but will have a span of about 1400 meters. This makes it unnecessary to place bridge pillars in the deep water of the navigation channel. The cantilever bridge would cost about 9 billion kroner in 1984 prices.³⁾

The motorail solution involves a tunnel that has two (7) tracks, placed on the ocean floor. It is four kilometers long. The motorail tunnel is estimated to cost about 5.5 billion kroner at 1984 prices.²⁾ -The alternative to a fixed crossing would be an integrated ferry service which would cost about 3.5 billion kroner in 1984 prices.³⁾ However, the interesting part is not the construction cost but the capital value of all in and out payments completed at the same time. These payments are, in "The 85 report", calculated and referred to 1995 with a discount interest of 7% p.a. and in "A fixed crossing" similarly calculated and referred to 1984, also with a discount interest of 7% p.a.. The capital values appear in Table 1, assuming a small and a large traffic increase (i.e., pessimistic, optimistic assumption respectively).

3) "A fixed crossing", page 46.

Table 1. Capital value of additional investments, operational savings and road-user advantages with fixed crossing.

Department of Public Works			
1995 account			
bridge	motorail	bridge	motorail
road/ rail	tunnel	road/rail	tunnel
low		high	
Billion kroner			
2.9	6.7	6.2	9.9
Nyboe Andersen Committee			
1984 account			
bridge	motorail	bridge	motorail
road/ rail	tunnel	road/ rail	tunnel
low		high	
Billion kroner			
0.5	2.0	3.6	4.4

Source: "The 85 report on the Great Belt" page 71 and
 "A fixed crossing" page 81.

Since all alternative solutions have a positive capital value at a real interest of 7% p.a., all solutions are socio - economically profitable. Calculated this way, the motorail solution has the best profitability. Social expenses as a result of possible environmental deterioration in the Baltic Sea are, as mentioned, not included in these profitability calculations because the assessment in this context is regarded as too uncertain. Also excluded are advantages that are deemed too uncertain. However, the calculations include the planning advantages for the industry and the advantages for the Danish State Railroad's rationalization. (8)

2. Calculations of salt and oxygen content in the Baltic Sea.

The ability of the Baltic Sea to support fishing depends on the salt and oxygen content of the water. This in turn depends on the influx of water through the Great Belt, in the water layers where the eggs are spawned and hatched. However, if a fixed crossing is completed, it will be very difficult to estimate how much the salt and oxygen content will be reduced and to what extent such a reduction will influence the fishing potential. Calculations carried out by LIC Consult indicate that ^{the} various solutions for the fixed crossing will cause small changes in the salinity in the Baltic Sea (less than 5%) in the areas of importance for recruitment. A cantilever bridge with spans of 780 meters will create the largest reduction, caused by the many pillars and embankment, followed by the suspension bridge and the tunnel. A suspension bridge with a wide span and few bridge pillars would reduce the salt

content the least amount. These calculations refer to layers of water where no eggs are present due to the limited content of salt, but it must be assumed that the calculations and the underlying model are applicable also to oxygen and salinity in the deeper layers of water where the eggs are spawned and hatched. There is a significant relation between oxygen or salt content in the relevant layers and recruitment to cod populations. The model calculations show that changes in salinity will be greatest in the upper and northeastern water layers and smallest in the lower and southwestern. In addition, during storms, the strong occasional inflows of water from the west will supposedly be uninfluenced by a fixed crossing. Based on the model already mentioned, changes (9) have been made in the various fixed crossing formulations, to study their negative effects on the Baltic Sea, and it has been shown that resistance against the current is not increased on the whole, and salinity is not decreased.⁴⁾ The increase in construction costs is 0.4 - 0.9 billions ⁵⁾, depending on which solution is chosen and whether the deepening of the Great Belt begins at once. The influence that the original plans would have on the salinity is between 0.3 and 0.7 per mille in the Bornholm Basin's upper water layers depending on the solution chosen,

4) Improvement of flow conditions. October 1985. ^{By} LICconsult & Associates for the Department of Public Works.

5) The figures cannot be directly compared with table 1 due to the different methods of calculation.

compared with an undisturbed state of 7.8 per mille. These changes may seem small, and the new plans may seem to be neutral having little influence on the environment. Nevertheless, possible negative consequences must not be underestimated. It should be remembered that the next step could be fixed crossings over Dresund and Fehmarn Belt .

The sum of the small effects of each project can be substantial.⁶⁾ A fixed crossing over the Great Belt will last for a long time. Therefore it would be important not to limit future development possibilities by choosing a solution that would have negative consequences for the Baltic Sea. An estimate of losses in increased value, due to reduced potential of the fisheries, will be presented later in this report. It can be considered an estimate of how large a socio-economic sacrifice can be made with advantage, in order to achieve solutions that would be neutral with respect to the Baltic Sea. Losses of increased value in the fisheries and their associated industries, without improvements (see subseq. text), must be compared with increases in construction costs for the improved solutions.

3. Catch in the Baltic Sea.

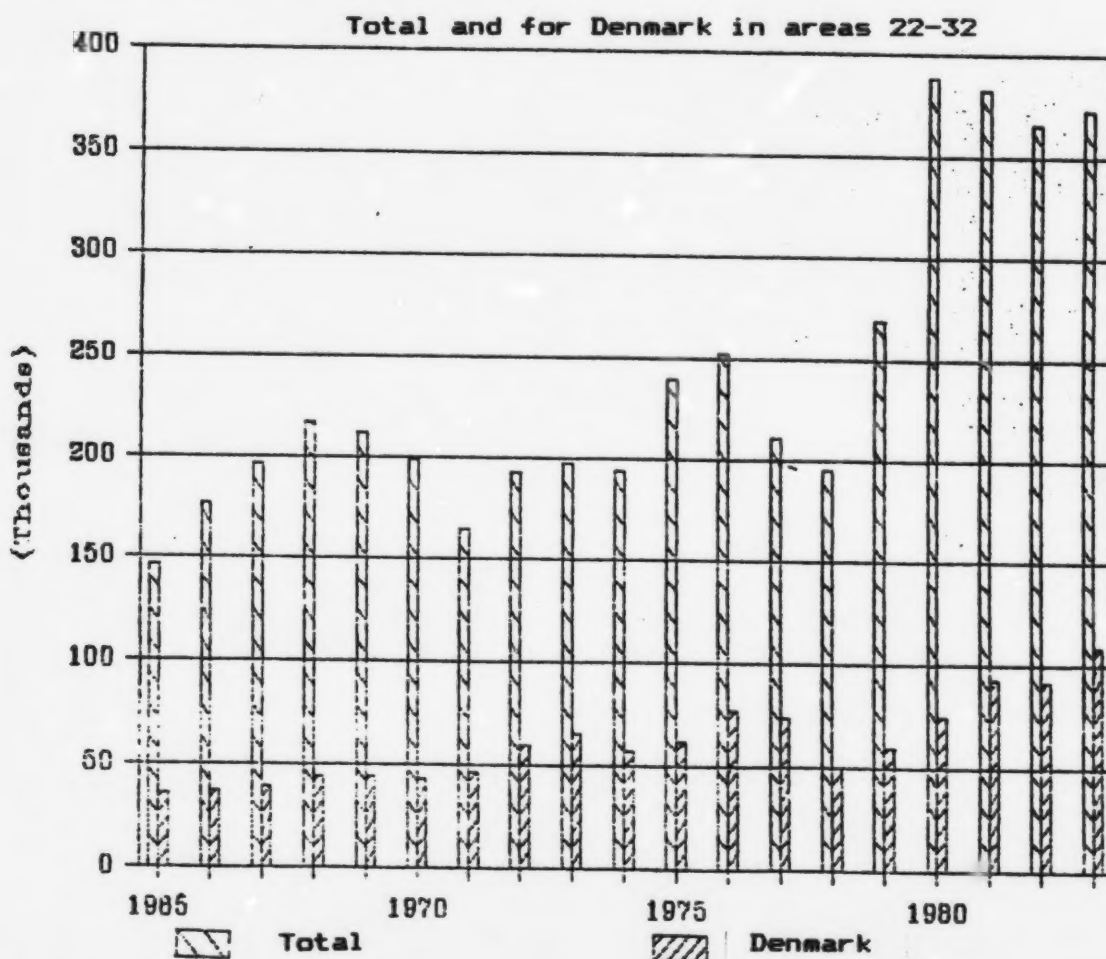
(10)

Cod is the most important fish species in the Baltic Sea and the species that will be most influenced by a reduction in salinity and oxygen content. Figure 1 shows the total cod catches

6) Torben Schelde Jacobsen. December 1980. Sea Water Exchange of the Baltic, Measurements and Methods. The Belt Project. Environment Directorate.

in the Baltic Sea compared to the Danish catch. Since 1980 the total catch has been significantly higher than in previous years. This has been caused by higher catches east of Bornholm in 1980 and 1981, especially by Poland and the USSR. Later these countries' catches decreased but that was compensated for with increases in Danish, Swedish, Finnish and West German catches.⁷⁾

Figure 1. Cod catches in the Baltic Sea.



Source: ICES, Coop. Res. Rep. 131.

7) ICES: Report to the International Baltic Sea Fishery Commission. Coop. Res. Rep. 131.

The Danish Catches have increased steadily through the last 20 years. The decrease in 1978 was not caused by the resource base but was due to strict quota regulations (see harbour blockades May 1978). The very large increase in the cod stock in 1976 created the base for a greater catch in 1978-82. But the increase in the catch after 1980 is without doubt due to an increase in fishing in the Baltic Sea by Common Market and other countries as a result of an extension of their fishery boundaries in 1977. This was followed by a tightening of quotas, especially in the North Sea, by the Common Market, resulting in the expulsion from Common Market waters of ships from third countries. This is related to a good market for cod during this period, which in itself resulted in a tendency to increased fishing activities and thereby greater catches in the short run. In the long run, cod catches in the Baltic Sea will hardly be maintained at this high level. A level of about 300,000 tons per year is more likely. (11)

Bornholm and the eastern part of Denmark depend very much on the cod fisheries. Likewise, many cutters from northern Jutland have participated in this fishery in later years. The fish-processing plants in Jutland have also received large quantities of cod from the Baltic Sea. It is likely that there has been a certain lack of reporting, resulting in official catch figures that underestimate the importance of the Baltic Sea. In addition, the import of cod to Denmark has increased significantly during recent years. In 1984 Denmark imported 50,000 tons of cod (cleaned weight) mainly from Sweden, West Germany, the Faeroe Islands and Finland. Most of this cod originated in the Baltic

Sea. Of the total Danish supply of cod (own landings + import) of about 240,000 tons live weight in 1984, it is realistic to estimate that about 180,000 tons originated in the Baltic Sea. It is estimated that this high level will be maintained in the future but only on the condition that if a possible Danish reduction takes place because of weaker recruitment (12)

(one ^{of several} pages missing. Translator's note.) . . .

... eggs ... at a depth of 50 - 70 meters and in the other areas at 80 - 100 meters.

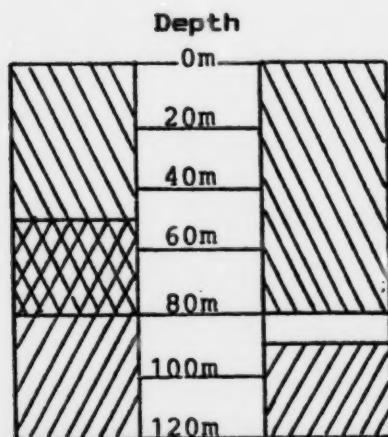
Diagram. Illustration of the conditions for hatching and growth of recruitment to cod populations in the Baltic Sea.

a.

Hatching
and growth possible

b.

Hatching
and growth not possible



-  Oxygen content greater than 50%
-  Salinity greater than 10%
-  Hatching and growth possible

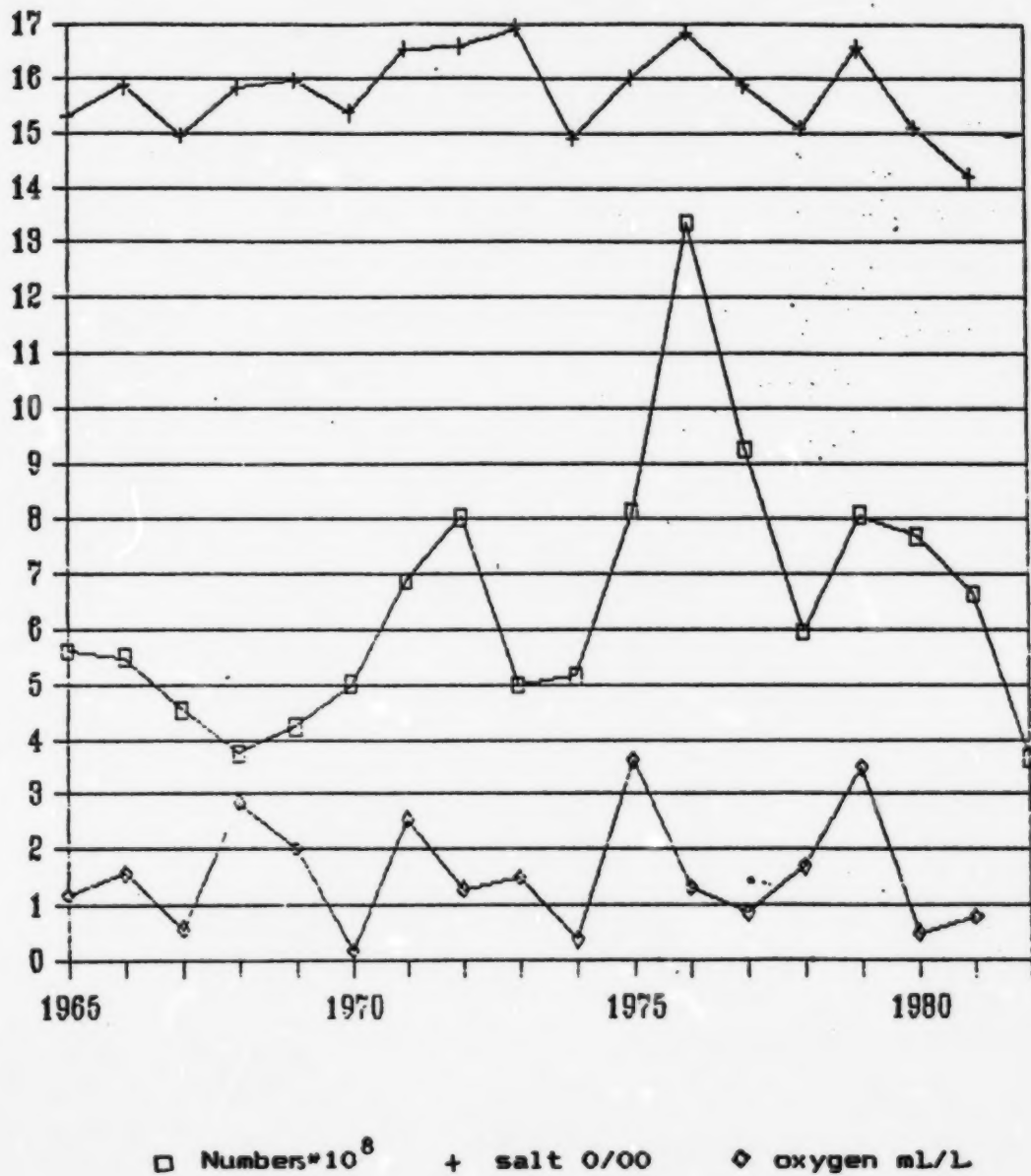
If the salinity declines, the eggs will only be able to float in the deeper layers or sink to the bottom. If oxygen pressure declines, the boundary for the hatching of eggs moves upward; see diagrams a and b. This means that the segment of the column of water where the necessary conditions are present, is reduced. Thus , conditions for spawning and hatching are impaired. This applies to Bornholm Deep , Gotland Deep , and Gdansk. It will be critical for the latter two, because they already have unfavourable conditions. The mortality rate for Bornholm Deep is listed at 91.1%; for Gdansk at 92.8; and for the southern, middle and northern areas of Gotland Deep at 93.5, 95.2, and 99.2%, respectively. The figures are averages for 1954-70, expressed as percentages. The available figures for recruitment, salinity, and oxygen content are very uncertain, and the following calculations can only hint at developments. DF & H's report establishes no specific model formulations. However, the report makes it clear that sustaining salinity and oxygen content levels is decisive for recruitment. Sustaining these conditions depends on the flow of saline, oxygenated water from Kattegat and exchange in the water columns mentioned, where water is relatively stagnant and not oxygenated by wind effects. No figures are available, so this model cannot be used. The explanatory power of the figures is impaired, when recruitment is used as a function of salinity or oxygen content, but a pattern can be established by comparing ^{the} time series of these variables. (13)

In Figure 2, salinities, oxygen contents, and annual recruitments are shown for the period 1965-1982. It shows clearly that in years with high salinity such as 1972, 1976, and 1979, there is

Fig. 2. Annual recruitment, salt and oxygen.

(14)

Cod in the Baltic Sea.



Source: See note 8.

a trend to higher annual recruitments than in years with low salinity, such as 1974, 1978, and 1981. An increase in the oxygen content reveals towards an increasing annual recruitment the next year, and vice versa when the oxygen content decreases. There also appears to be a covariation between oxygen content one year and salinity in the following year. A likely explanation can be that these changes have a common cause in the form of exceptionally strong exchanges of water due to unusually frequent storms forcing water in and out of the Baltic Sea. Danish Fishery and Ocean Research, in its previously mentioned report, studies the covariation between different salinities and oxygen contents on the one hand and annual recruitments on the other.

In all cases there exists a positive covariation and significant correlation between the annual recruitment of a year and salinity during in the spring months. Further, there is a significant correlation between recruitment in a given year and oxygen content in the previous year. If regression analyses are carried out to measure the magnitude of the change in annual recruitment at a given change in salinity, they show that an increase in salinity from January to June of 1 per mille results in a change in the annual recruitment amounting to 153 mill. fish in the same year.⁹⁾ A change in oxygen content in a given year of 1 milliliter per liter gives a change of 140.6 mill. fish in the annual

9) Regression for the period 1972-81 shows a slope (β) of 1.52989×10^8 , an intersection (α) of $-1,63733 \times 10^9$ and a t-value of 1.90233.

recruitment of the year after 10). However, a simple regression or a multiple regression including several of the variables mentioned indicates that there are other important variables that have been excluded. The reliability of the use of a simple or multiple correlation coefficient is therefore low.¹¹⁾ It is to be expected that meteorological conditions and the size of the spawning stock also play a role.

Looking at the fluctuations in salinity in Figure 2 compared with the calculated changes of salinity due to a partial blockading of those water layers in the Great Belt that carry the in-coming saline flow, it seems reasonable to calculate a loss in catch based on a reduction in the average salinity of 0.5 per mille. This means that according to the regression calculations, the annual recruitment is reduced on an average by 76.5 million cod. The loss in catch can be calculated with the following formulas:

$$\begin{aligned}
 W_t &= 6 \cdot (1 - e^{-k(t+3)})^3 \\
 C_t &= R \cdot \left(\frac{f}{f+m}\right) \cdot (1 - e^{-(f+m)}) \cdot e^{-(f+m)t} \\
 l_t &= W_t \cdot C_t
 \end{aligned}$$

where W_t is the weight of the cod at the age of t ,¹²⁾, C_t is (16)
the number of cod caught per age group, and l_t is the product

10) A regression for the period 1972-82 shows a slope (β) of 1.40592×10^8 . An intersection (α) of 5.04595×10^8 and a t -value of 2.2779.

of these two and the catch measured by weight in each age group. If l_t is summed over all age groups, the weight of the total catch of cod is obtained for one year.

In case of a long-term decline of 76.5 mill. cod in annual cod recruitment, it is possible, with this model, to calculate total loss in catch in areas 25-32 at 42,000 tons per year.¹³⁾ The socio-economic value of the cod catch has been calculated in order to judge the impact upon Denmark of such a reduction in the cod catch from the Baltic Sea.

5. The socio-economic value per kg cod.

The value lost through a decline in the cod fishery can be calculated by looking at the magnitude of value growth per kg cod.

One kilo of cod landed by Danish fishermen has a value for the captain and his crew in the form of wages and net income. The part of the cod catch that is processed, benefits the fishing industry. Increased activity in the fisheries and the fishing industry will result in income for sectors that service the two activities.¹⁴⁾ The input-output model of the Fishery Economics Institute shows that the total value growth per 1 kg cod can be calculated to 12.05 kroner. The direct effect in the form of income to the fishery and fishing industry is 8.21 kroner and the indirect effect created by the demand of the fishery sector for commodities from other sectors is 3.84 kroner.¹⁵⁾ All figures are based on 1984 prices.

(17)

The assumption behind this calculation is that on the average, the cod is utilized in the same manner as at present and that a decline in the Danish supply of cod cannot be compensated by imported cod. A decline in the cod fisheries will

effect the whole Baltic Sea area where most of the Danish processed cod originates. The above condition is therefore assumed to be valid. Cod from other waters such as those of Norway, will not be attractive in the long term because of the cost of transportation to existing Danish factories. If imports compensate part of the Danish catch and processing remains the same, the social value will be reduced with a loss for the Danish fisheries of 4.35 kroner. Assuming that $1/3$ of the reduction in the cod fisheries is compensated with imported cod, the total average loss per kg cod will be 9.84 kroner.

11) Correlation coefficients for the above regressions are 0.56 and 0.60 respectively.

12) $t = 0$ for the age at which cod is included in cod fishery: in the Baltic Sea, this age is 2 - 3 years.

13) f is fish mortality, here estimated at 1.5; k is growth coefficient, here fixed at 0.2; m is natural mortality which in the DF&H report is fixed at 0.3; r is recruitment, fixed at the change in recruitment, i.e., 76.5 million fish.

6. Socio-economic loss.

A cantilever bridge, a suspension bridge (1400 meter main span), and a submerged tunnel will all strongly reduce the East Channel flow cross section at the bridge, depending upon whether protective islands are built around the bridge pillars or if these pillars are only protected against collision.¹⁶⁾ With collision-protected bridge pillars, the present total $96\ 000\text{-m}^2$ flow area in the East Channel will be reduced by 18% and 17% respectively for the two types of bridges (including embankments). Use of protective islands around the anchor pillars will reduce the flow by 23% and 19% respectively, and still more reduction will occur if protective islands are used around all bridge pillars. A submerged tunnel will reduce the flow by up to 25%. (18)

As mentioned, calculations have shown (see p.11) that with increased construction costs, fixed crossings can be built so that they do not cause changes in the salinity of the Baltic Sea. This can be done by shortening embankments, changing the pillar shape, modelling the coast, and carrying out deepening in eastern

14) In order to meet the increase in demand, the suppliers must increase their production and their demand for products of other sectors. The total effect is calculated with a specific input-output model. The landing price is assumed to be 7 kroner per kg.

15) Fishery Economics Institute's input-output model^{is}, based on a model by Statistics Denmark, is drawn up by the same principles, and has a specific detailed section for the fishing sector.

and western channels. The additional costs, amounting to 0.4-0.9 billions, can, as mentioned, be compared with the additional costs to society in the form of losses to the fisheries, if these changes were not carried out. In such an event, a decrease in salinity of 0.5 promille point would be expected. This would equal a 3-4% drop in the relevant water layers. This would result in an annual loss in the cod catch east of Bornholm of 42,000 tons (see p.20). Since Denmark catches about 1/4 of its cod east of Bornholm, the Danish loss would be about 10,500 tons annually. This estimate is based upon an assumption of no reduction in cod fishing west of Bornholm, and losses of other countries are not included. It is also assumed that other countries are not supposed to be granted compensations at the annual negotiations concerning the allocation of quotas for cod. It is presumed that 1/3 of the Danish loss can be compensated for with imports and that the present importation of 60,000 tons can be sustained, although^{at least}_A the fishing industry in Bornholm would find it difficult to compensate for the loss of cod by means of another type of fish. This will cause a loss in value growth for Denmark at all stages, of 2/3 of the 10,500 tons, and a loss of value growth in the fisheries of 1/3 of the 10,500 tons. The total losses in value growth can be calculated as follows:

10,500 x 9.48 kr $\approx$ 100 million kr annually

16) Gimsing, N.J. (1984): The Great Belt bridge/tunnel.
Technical Publishing Co., Copenhagen.

This loss will continue into the future and will be fully realized by 1997, if construction of the fixed crossing is completed as assumed, with an opening scheduled for 1.1.1995. The future loss, computed from 1997 and discounted back to 1984, will amount to 593 million kroner. This figure can be compared with the figures from ^{the} Nyboe Andersen Committee. It will be of benefit to society to use up to this amount of money to improve a fixed crossing in order to avoid negative effects on future fishing. This estimate concerns only cod. (19)

Sprat is an important species, spawning under conditions similar to those of cod. Sprat is not as valuable as cod but constitutes feed for the cod. If the sprat stock is reduced, the feeding base for cod is reduced. Herring, which would be minimally influenced by a fixed crossing, can to a certain extent replace sprat, and thus the influence of a reduction in the sprat stock will be of less importance. However, to include only the Danish loss and not the losses of other countries is hardly reasonable. The loss of all other countries is assumed to be three times that of Denmark, since value growth in the other countries is assumed to be less per kg than in Denmark.

It is easier in the long run to find alternative uses for work force and capital, although not so much in Bornholm as in other parts of the country. The loss in value growth cannot therefore directly be converted into increased unemployment. A capital value of 593 million kroner of future losses in catch is not a sum to make any of the alternatives in Table 1 unprofitable. The Nyboe Andersen committee's

calculation for a bridge for both road and rail has a capital value of about 500 million kroner under an assumption of slow growth and will have negative capital value if the losses in catches are included. The real interest of this solution will therefore be less than 7%; however, it is always

possible that a long-term investment

has a high interest. - The discussions have not mentioned anything about the distribution of possible consequences. Some regions and populations will benefit and others will lose. Certainly those employed in the fishing and fish processing industries in Bornholm will lose. The same will apply to the fishermen and fishing industry in Zealand and the southern isles. However, it cannot be established conclusively that other sections of the Danish fisheries and fishing industry will suffer a net loss if the fishing potential of the Baltic Sea is reduced as a result of the construction of a fixed crossing over the Great Belt. (20)

Therefore, the conclusion is, that if the so-called optimum solutions for an economical construction of a fixed crossing over the Great Belt are chosen, the socio-economic profitability calculations must take into account possible losses of 593 mill. kroner for the cod fishery, in 1984 prices.

This means that an amount of this magnitude is gained if the fixed crossing is constructed in a way that will not negatively influence the Baltic Sea. If the losses that the Baltic Sea countries will suffer are included, it can be estimated that the gain will be approximately three times greater. This gain can be compared with the increased

construction costs necessary to prevent any negative impact the fixed crossing may have on the Baltic Sea, and the comparison will show that it may be a good bargain for society to carry out these improvements.